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Bryozoans from the Llanbedrog Mudstones (Caradoc), north Wales.

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CONTENTS

Synopsis. A diverse bryozoan fauna is described from the Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, north Wales. The fauna is dominated by trepostomes (nine species), although one cystoporate and one cyclostome species are present. Three new trepostome species, *Stigmatella oakleyi*, *Pedrogopora taylori*, and *Diplotrypa nontabulata* are described; *Pedrogopora* is a new genus.

A lectotype for *Prasopora grayae* Nicholson & Etheridge 1877 is selected.

INTRODUCTION

Bryozoans are one of the major components of Ordovician faunas. Whilst they are well known from North America and the Soviet Union, their study has been largely neglected in Britain. This neglect may be partly attributed to poor preservation and the time taken to prepare specimens, and partly to the lack of any strong tradition of bryozoan research in Britain. Bryozoan specimens from the Ordovician of Britain are commonly present in museum collections (e.g. Natural History Museum, Sedgwick Museum and British Geological Survey), but they are usually decalcified moulds. This makes them difficult to identify even to family level. Calcified specimens frequently go unnoticed in the field except where a large proportion of the rock consists of bryozoans.

MATERIAL

The Llanbedrog Mudstones (Soudleyan, Caradoc) crop out on the western side of the A449 road south of Llanbedrog, Gwynedd, north Wales (National Grid Reference SH 322314). Fossils are unevenly distributed throughout the rock, a calcareous mudstone. Bands of decalcified bryozoans can be identified on the surface of the outcrop. When these regions were excavated calcified colonies were revealed. Brachiopods (e.g. *Leptaena* sp.) and trilobites (e.g. *Calymene* sp. and *Illaenus* sp.) were also found at this locality.

Matley (1938) described the geology of the area around Pwllheli, Llanbedrog and Madryn. This includes a description and faunal list of the Llanbedrog Mudstones. Recorded on the list are 'cf. *Monticulipora lens* auct., *Ptilodyctya*? and indeterminate polyzoa'; no illustrations are included.

The material examined here comprises specimens collected recently in the field, and a Natural History Museum collection from the same locality made by the late Dr K. P. Oakley. The Oakley collection includes thin sections prepared from over thirty specimens.

The bryozoan fauna is diverse, consisting of 11 species, three of which are new. Trepostomes dominate with nine species, but one cystoporate and one cyclostome species are also present. The cyclostome species is very small and quite abundant but has only been recognized in randomly orientated peels. Only a brief description of this species is included herein (p. 167) because it has recently been described in full elsewhere (Buttler 1989).

Table 1 Summary of the biometric details of all trepostome species from the Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. In each case, upper left figure is the mean, followed by the number of specimens in brackets. Lower figures are the range. All measurements are in millimetres except for ZMM, CMM, AZ and AMM (*). ZOW = zoarial diameter, EXW = exozonal width, MXZD = maximum autozooecial diameter, MNZD = minimum autozooecial diameter, MXMD = maximum mesozooecial diameter, ZWT = autozooecial wall thickness, ZMM = autozooecia per mm, DEX = distance between exozonal autozooecial diaphragms, DEN = distance between endozonal autozooecial diaphragms, DMEX = distance between exozonal mesozooecial diaphragms, DMEN = distance between endozonal mesozooecial diaphragms, CMM = number of cystiphragms per mm, AD = acanthostyle diameter, AZ = number of acanthostyles per autozooecium, AMM = acanthostyles per square mm.

Species	ZOW	EXW	MXZD	MNZD	MXMD	ZWT	ZMM *	DEX	DEN	DMEX	DMEN	CMM *	AD	AZ *	AMM *
Stigmatella oakleyi	8·26 (9) 4·0–15·0	1·79 (34) 1·14–2·85	0·29 (36) 0·17–0·48	0·2 (36) 0·11–0·32	0·12 (36) 0·04–0·23	0·06 (34) 0·02–0·11	9·12 (36) 5·5–13	0·15 (36) 0·06–0·36	0·31 (1) 0·25–0·4	0·1 (36) 0·04–0·21	–	–	0·04 (34) 0·02–0·08	2·86 (34) 1–6	21 (28) 8–34
Pedrogopora taylori	5·57 (7) 4·0–8·0	1·67 (4) 1·24–2·28	0·36 (6) 0·23–0·51	0·24 (6) 0·15–0·4	0·14 (6) 0·04–0·29	0·14 (6) 0·08–0·23	4·73 (6) 4–5·5	0·19 (1) 0·19	–	0·09 (7) 0·04–0·21	–	–	0·06 (5) 0·04–0·09	6·73 (3) 5–9	8·67 (2) 7–10
Diplotrypa pseudopetro-politana	–	–	0·44 (1) 0·42–0·46	0·35 (1) 0·32–0·4	0·16 (1) 0·1–0·23	–	4·75 (1) 4·5–5	–	0·53 (1) 0·38–0·68	–	0·07 (1) 0·04–0·1	–	–	–	–
Diplotrypa nontabulata	9·5 (2) 9·0–10·0	–	0·44 (4) 0·3–0·57	0·38 (4) 0·27–0·48	0·23 (4) 0·08–0·44	–	–	5·83 (4) 4·5–7·0	–	0·15 (3) 0·1–0·3	0·16 (3) 0·08–0·23	–	–	–	–
Hallopora cf. *tolli*	5·0 (1) 5·0	0·86 (1) 0·86	0·31 (1) 0·27–0·34	0·23 (1) 0·17–0·32	0·13 (1) 0·08–0·19	0·08 (1) 0·06–0·1	6·83 (1) 6·5–7	0·11 (1) 0·08–0·17	0·21 (1) 0·17–0·25	0·05 (1) 0·04–0·06	0·07 (1) 0·06–0·1	–	–	–	–
Eridotrypa cf. *kilbartiensis*	2·5 (1) 2·5	0·76 (1) 0·76	0·12 (1) 0·11–0·13	0·1 (1) 0·1–0·11	–	–	–	0·11 (1) 0·08–0·13	–	–	–	–	–	–	–
Prasopora grayae	11·0 (2) 10·0–12·0	–	0·41 (2) 0·34–0·51	0·31 (2) 0·29–0·36	0·13 (1) 0·08–0·17	–	6·67 (2) 5–9	0·12 (1) 0·08–0·23	0·1 (2) 0·04–0·13	–	0·06 (1) 0·04–0·1	8·91 (2) 7–11	–	–	–
Prasopora thorali	30 (1) 30	–	0·43 (2) 0·29–0·55	0·35 (1) 0·27–0·48	0·14 (2) 0·08–0·23	0·029 (2) 0·02–0·06	5·55 (2) 3–8	0·14 (2) 0·06–0·23	0·17 (2) 0·1–0·29	–	0·1 (2) 0·08–0·13	6·21 (2) 5–8	–	–	–
Mesotrypa sp.	8·0 (1) 8·0	–	0·34 (1) 0·27–0·42	–	0·17 (1) 0·13–0·19	–	–	–	–	0·11 (1) 0·1–0·13	0·12 (1) 0·06–0·19	–	0·04 (1) 0·04–0·05	–	–

A total of nine genera have been described from the Caradoc Llanbedrog Mudstones. Only one of these, *Pedrogopora* gen. nov. (p. 157), is endemic to north Wales; all the rest are cosmopolitan, known from North America and Baltoscandia. A wide generic dispersal may have been caused by a long-lived planktotrophic larval phase which encouraged dispersal. Taylor & Cope (1987) consider that early stenolaemates may have inherited this phase from their ctenostome ancestors.

Four of the total 11 species have not been previously described outside north Wales. Three of these species are new and one has been left in open nomenclature. It is impossible to tell if this apparent endemism reflects the true condition, or is the result of selective preservation and/or sampling.

Three species, *Hallopora* cf. *tolli*, *Ceramoporella distincta* and *Kukersella borealis* have very broad biogeographical ranges. They are known from both North America and Baltoscandia. The majority of the British Isles was separated, during the Lower Ordovician, from North America (Laurentia) by the Proto-Atlantic Iapetus Ocean. Pickering *et al.* (1988), using a variety of palaeontological, stratigraphical, structural, geophysical and igneous evidence considered that by the end of the Ordovician the Iapetus Ocean was partially closed, with only narrow marine seaways persisting to the Middle Silurian. During the Caradoc the Iapetus did not form an impenetrable barrier to bryozoan dispersal. *Prasopora grayae* is also known from both sides of the Iapetus, because Scotland was located on the Laurentian margin.

SYSTEMATIC PALAEONTOLOGY

The terminology in all descriptions is that of Boardman *et al.* (1983). Trepostomata genera are placed in families based on Astrova (1978) and Cystoporata genera on Utgaard (*in* Boardman *et al.* 1983). Family level classification is generally unsatisfactory in Palaeozoic trepostomes and is currently being revised for the Treatise on Invertebrate Paleontology by R. S. Boardman.

Three taxa could not be conclusively identified to specific level. In these cases the species are referred to as 'cf.' and 'sp.', based on the recommendations of Bengston (1988).

Biometric details for all trepostome species are tabulated (Table 1). Each measurement was made up to seven times per specimen. The mean and range are calculated for each parameter. Raw data can be found in the author's unpublished Ph.D. thesis (Buttler 1988). All specimens are thin sections or acetate peels.

Phylum BRYOZOA Ehrenberg, 1831
Class STENOLAEMATA Borg, 1926
Order **TREPOSTOMATA** Ulrich, 1882
Suborder **HALLOPOROIDEA** Astrova, 1965
Family **HETEROTRYPIDAE** Ulrich, 1890

Genus ***STIGMATELLA*** Ulrich & Bassler, 1904

Stigmatella oakleyi sp. nov. Figs 1–4, 8

HOLOTYPE. BMNH PD 2641; Llanbedrog Mudstones Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales SH 322314).

PARATYPES. BMNH PD 2639, 2655, 2658, 2664, 2664a, b, 2665–74, 2685–6, 2688, 2692–3, 2695, 2701, 2716, 2718, 8283–96; all from the same horizon and locality as the holotype.

NAME. For the late Dr K. P. Oakley, formerly of the Natural History Museum, who first collected and sectioned trepostome bryozoans from the Llanbedrog Mudstones.

DIAGNOSIS. Colony large, ramose. Autozooecia have very thin, wavy walls in endozone, are parallel to branch axis, and then curve out abruptly to zoarial surface. Zooecial walls thicken irregularly in exozone. Autozooecia polygonal in transverse section, rounded to petaloid in shallow tangential section. Polygonal-rounded mesozooecia common, originating in the outer endozone and inner exozone. Diaphragms present in exozonal autozooecia, common in mesozooecia. Acanthostyles abundant in exozone.

DESCRIPTION. Zoaria erect with cylindrical branches, on average 8·26 mm in diameter. The surfaces of all specimens are abraded. Autozooecia meander but generally are parallel to the branch axis at the centre of the colony. They curve outwards abruptly in the outer endozone and meet the zoarial surface at 90°. Autozooecia within the endozone have very thin walls.

The exozone is usually thick, with an average diameter of 1·79 mm. It is recognized by simultaneous irregular thickening of the zooecial walls and a change in zooecial orientation. Transverse sections of autozooecia are polygonal in the endozone, becoming rounded to petaloid in the exozone, as seen in shallow tangential sections. Autozooecial diameters average 0·20 mm × 0·29 mm in the exozone. Orally-deflected basal diaphragms are rare to absent in the endozone but present within the autozooecia in the exozone, where they are spaced on average 0·15 mm apart.

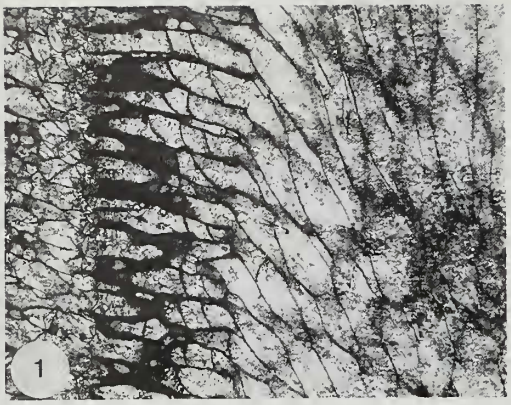
Mesozoecia are common and originate in the outer endozone and exozone. They are polygonal-rounded in shallow tangential sections and have a maximum diameter which averages 0·12 mm. Orally-deflected basal diaphragms are common in the mesozooecia, spaced on average 0·1 mm apart. In the outer endozone/inner exozone the mesozooecia are thinner and constricted at the positions of the diaphragms, producing a beaded appearance.

Acanthostyles are short and abundant, with an average diameter of 0·04 mm and density of 21 per mm^2. They originate throughout the exozone and frequently indent the zooecial apertures, producing a pronounced petaloid shape. A hyaline core is surrounded by steeply dipping conical laminae.

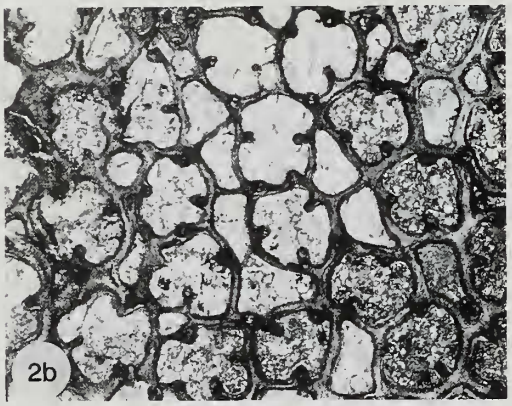
Autozooecial wall thickness averages 0·06 mm in the exozone. Wall microstructure is composed of inclined U-shaped laminae. Zooecial wall boundaries consist of wide regions of granular calcite. The microstructure is frequently disrupted by large acanthostyles. Some zooecia, especially mesozooecia, are infilled with laminar calcite close to the zoarial surface. In longitudinal section this infilling consists of broad U-shaped laminae.

It is common to find hollow 'cyst-like' structures within autozooecia in some zoaria (Figs 4b, c). These are spherical, average 0·05 mm in diameter, and occur singly or in groups. They are attached to the sides of the zooecial walls or to the centre of diaphragms, and their laminae are continuous with zooecial linings.

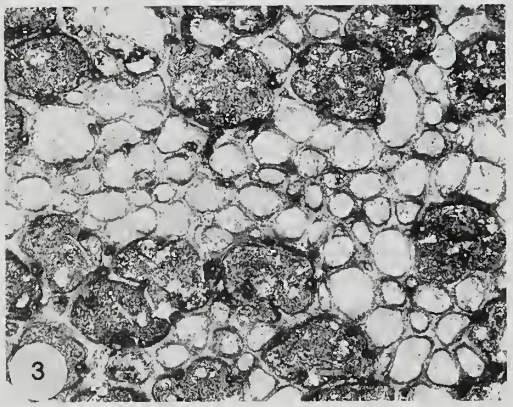
Maculae, consisting predominantly of mesozooecia, have been observed in shallow tangential section (Fig. 3). Large


1


2a


2b


2c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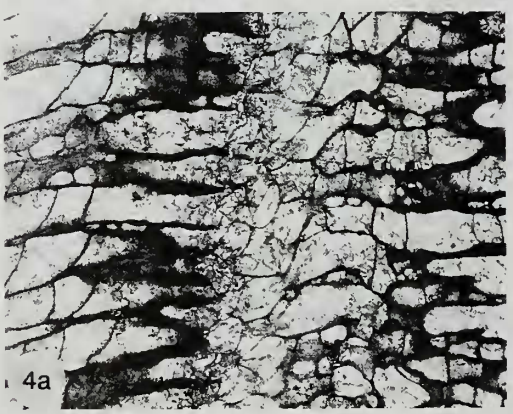
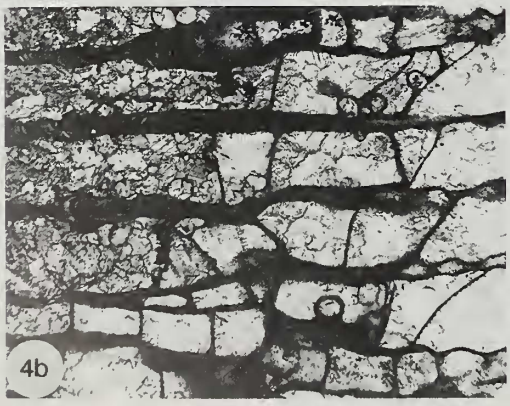

4a


4b


4c

intraspecific overgrowths are common and are composed of exozonal and outer endozonal elements.

REMARKS. *Stigmatella oakleyi* sp. nov. is primarily characterized by the erect colony form and very thin endozonal walls which thicken irregularly in the exozone. The acanthostyles are very abundant and frequently indent the autozooecial apertures producing a petaloid shape. Mesozooecia are common and have abundant diaphragms.

Stigmatella has not previously been described from Great Britain, although it is well known from North America and the U.S.S.R. *Stigmatella foordi* (Nicholson, 1889) from the Ordovician of Estonia has similar abundant acanthostyles which indent the autozooecial apertures. *S. foordi* can be distinguished by the hemispherical colony form, smaller acanthostyles, straight mesozooecia and less extensive thickening of the exozonal walls.

S. spinosa Ulrich & Bassler (Ulrich & Bassler 1904: pl. ix, figs 5–8; see also Bork & Perry 1968: pl. 48, figs 3–5), described from the Middle Ordovician of Iowa, has an irregularly thickened exozone which is similar to that of *S. oakleyi*. It differs from the Welsh species by having a greater number of diaphragms in the autozooecia, fewer mesozooecia, and acanthostyles which do not inflect the autozooecial apertures.

Genus ***PEDROGOPORA*** nov.

TYPE SPECIES. *Pedrogopora taylori* sp. nov.; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

NAME. After Llanbedrog (= Church of St Pedrog), the nearest town to the type locality.

DIAGNOSIS. Colony ramose. Autozooecia parallel to branch axis in endozone, then curve abruptly outwards to intersect zoarial surface. Walls very thin and wavy in the endozone, greatly thickened in exozone. Autozooecia compressed rounded-polygonal, vesicular appearence in transverse section, oval-circular to slightly petaloid in shallow tangential section. Oval mesozooecia common, some with extremely thin walls, originating in outer endozone and inner exozone. Diaphragms rare in autozooecia, present in exozonal mesozooecia. Acanthostyles abundant in exozone.

REMARKS. *Pedrogopora* is primarily characterized by its wall structure. The autozooecia within the endozone have very thin walls and often have an unusual vesicular appearance. In the exozone the walls increase greatly in thickness. Mesozooecia often have exceptionally thin walls and have the appearance of simple space-filling structures between the autozooecia (Fig. 6d). Wall microstructure is composed of steeply inclined, V-shaped laminae and zooecial wall boundaries are dark and granular.

The genus is similar to *Leioclema* Ulrich, 1882 but the latter does not have such wide variation in wall thickness between the exozone and endozone. Thin-walled mesozooecia are also not recognized in *Leioclema*.

The monotypic genus is currently known only from the Upper Ordovician, at the type locality.

Pedrogopora taylori sp. nov. Figs 5–6, 8

HOLOTYPE. BMNH PD 2642; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

PARATYPES. BMNH PD 2646A, 2700, 8298–302; all from the same locality and horizon as the holotype.

NAME. For Dr P. D. Taylor of the Natural History Museum, for his work on bryozoans.

DIAGNOSIS. As for genus.

DESCRIPTION. Zoaria erect with cylindrical branches, on average 5·6 mm in diameter. Autozooecia are parallel to the branch axis within the endozone and then curve outwards abruptly in the exozone to meet the zoarial surface at 90°. Autozooecial walls within the endozone are exceptionally thin and slightly wavy. The exozone is usually wide with an average width of 1·67 mm. It is recognized by a thickening of the zooecial walls and a simultaneous change in zooecial orientation. Autozooecia all originate in the endozone where they have an irregular, compressed, rounded-polygonal shape in transverse section; some autozooecia have a vesicular appearance. They become oval-circular to slightly petaloid in the exozone, as seen in tangential sections of branches. Autozooecial diameters average 0·24 mm × 0·36 mm within the exozone. Diaphragms are rare or absent in autozooecia and, when present, only one or two are found in the exozone. They are basal diaphragms deflected orally at their junctions with the zooecial walls, and have laminae continuous with autozooecial linings.

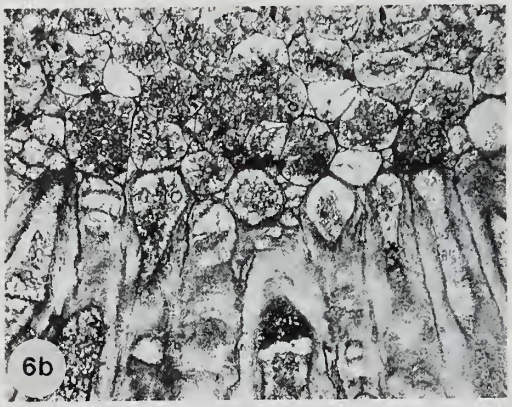
Mesozooecia are common, originate in the outer parts of the endozone and inner parts of the exozone, and have an average diameter of 0·14 mm. Wall thickness varies considerably, and while some mesozooecia have a distinctly laminar wall, others have exceptionally narrow walls and appear to be simple space-filling structures between the autozooecia (Fig. 6d). Mesozooecia are oval in shallow tangential section, and contain orally-deflected basal diaphragms in the outer endozone and exozone. The diaphragms are spaced on average 0·09 mm apart and generally increase in thickness distally along the mesozooecium.

Acanthostyles are abundant with an average diameter of 0·06 mm and density of 7 per mm^2. They are long, originate deep in the exozone and can occasionally indent the autozooecial apertures to produce a petaloid shape. They are usually found at the junctions of three or more zooecia but

igs 1–4 *Stigmatella oakleyi* sp. nov.; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. Fig. 1, BMNH PD 2670 (paratype), longitudinal section, showing very thin endozonal walls, × 20. Fig. 2, BMNH PD 2641 (**holotype**); 2a, transverse section, × 25; 2b, tangential section, showing large acanthostyles inflecting the autozooecia, × 45; 2c, tangential section, showing microstructure, × 110. Fig. 3, BMNH PD 2664 (paratype), tangential section, showing maculae consisting predominantly of mesozooecia, × 35. Fig. 4, BMNH PD 2670 (paratype); 4a, longitudinal section showing interzoarial overgrowth, × 28; 4b, longitudinal section showing 'cyst' structures in the exozone, × 50; 4c, longitudinal section showing a cluster of 'cyst' structures in the exozone, × 145.


5


6a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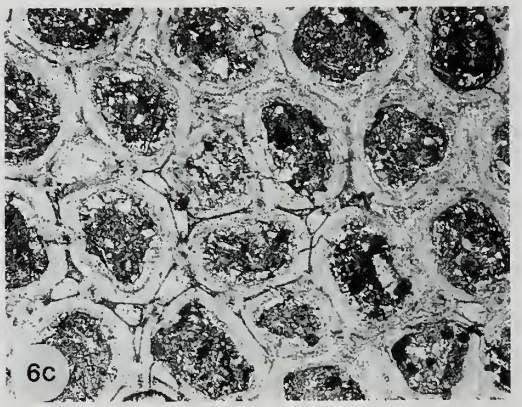
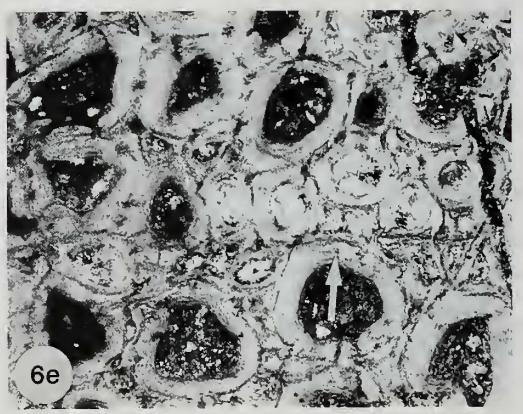
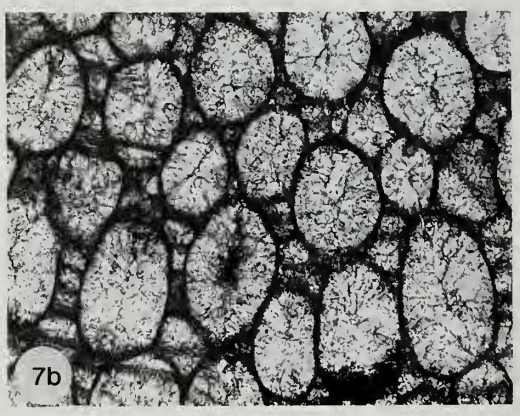

6c


6d


6e


7a


7b

also occur in the walls between adjacent zooecia. A narrow hyaline calcite core is surrounded by steeply dipping conical laminae.

Autozooecial wall thickness averages 0·14 mm in the exozone. Wall microstructure is composed of steeply inclined, V-shaped laminae and zooecial wall boundaries are dark and granular. Some zooecia, especially mesozooecia, are infilled with laminar calcite close to the zoarial surface. In longitudinal section this infilling consists of broad U-shaped laminae.

Maculae composed of mesozooecia have been recognized in shallow tangential thin section in one specimen (PD 2642, Fig. 6e). Intrazoarial overgrowths have been recognized in several specimens (e.g. PD 8302) and they are composed of outer endozone and exozonal elements.

Remarks. This is the only species of *Pedrogopora* so far recognized. Within the species there is variation in the width of the endozone from 2·28 mm (in the type specimen PD 2642) to 0·86 mm (in PD 8299). The thin-walled mesozooecia are not observed in all specimens.

Family **HALLOPOROIDAE** Bassler, 1911

Genus ***DIPLOTRYPA*** Nicholson, 1879

Diplotrypa pseudopetropolitana Astrova, 1965 Fig. 7

1948 *Diplotrypa petropolitana* (Nicholson); Astrova: 16; pl. 2, figs 4–5; pl. 3, fig. 1.
1965 *Diplotrypa pseudopetropolitana* Astrova: 189; pl. 30, fig. 3; pl. 31, fig. 1.
1970 *Diplotrypa pseudopetropolitana* Astrova; Nekhorosheva: 75; pl. 1, fig. 4.

Holotype. H No 1244/40, Yugorskiy Stage (Caradoc), Pai-Khoi and Vaigach Id, Zapadno-Arktichenskoy, U.S.S.R. (Astrova 1948).

Material examined. BMNH PD 2626, Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314); D 28581, 'Bala Limestone', Gelli Grîn, Gwynedd, Wales.

Description. Zoaria are hemispherical in the fragmentary specimens examined. Autozooecia originate at the centre of the colony and curve outwards towards the zoarial surface. Autozooecial walls are straight and thin throughout most of the colony. There is no differentiation between endozone and exozone. The autozooecia are rounded in transverse section throughout the zoaria, with an average maximum diameter of 0·44 mm in the exozone. Diaphragms are present, although not abundant, along the whole length of the autozooecia. These are basal diaphragms deflected orally at their junctions with the zooecial walls.

Mesozooecia are numerous and originate throughout the colony. They are rounded in transverse section and have a maximum diameter which averages 0·16 mm. Mesozooecia contain very abundant, orally-deflected, basal diaphragms along their entire length; they are spaced on average 0·07 mm apart and increase very slightly in thickness at the distal end of the mesozooecia. Cystiphragms are occasionally present instead of diaphragms throughout the mesozooecia; they occur on alternating sides of the mesozooecia.

Autozooecial walls are thin and the wall microstructure is composed of inclined U-shaped laminae. Zooecial boundaries are wide granular regions, most clearly seen in shallow tangential sections.

Remarks. *Diplotrypa pseudopetropolitana* Astrova, 1965 has been described previously from Vaigach Id and Pai-Khoi in the Soviet Union by Astrova (1965) and Nekhorosheva (1970). Astrova distinguished the new species from the similar *D. petropolitana* (Nicholson, 1879) by the presence of rounded (not polygonal) autozooecial apertures and more abundant mesozooecia. *D. petropolitana* is a frequently described species, with several recorded varieties and subspecies. It is very variable, especially in the number and distribution of diaphragms within the autozooecia. *Hallopora? dybowskii* Bassler, 1911 is extremely similar to *D. petropolitana*, as Bassler himself remarked (1911: 336), and should be synonymized.

D. nontabulata sp. nov. (below) is also described from Llanbedrog. It differs from *D. pseudopetropolitana* by having rare diaphragms within the autozooecia.

Only one species of *Diplotrypa* has been previously described from Great Britain. This is *D. hvergelmi* McNamara, 1978 from the Applethwaite Beds (Ashgill) of Troutbeck in the Lake District. This species has sinuous walls, with diaphragms widely spaced throughout the zooecia.

Diplotrypa nontabulata sp. nov. Figs 8–9

?1968 *Diplotrypa* sp. Bork & Perry: 340; pl. 45, figs 1–3.

Holotype. BMNH PD 8175; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

Paratypes. BMNH PD 2697, 2719, 8174; all from same locality and horizon as the holotype.

Other occurrence. ? Guttenberg Formation (Caradoc), Guttenberg, Iowa, U.S.A.

Name. In consideration of the lack of diaphragms within the autozooecia.

Diagnosis. Colony hemispherical. Zooecia have straight, thin walls and are budded from the basal lamina. No differentiation between endozone and exozone is recognized. Autozooecia large, polygonal-circular in transverse section throughout zoaria. Polygonal mesozooecia present. Diaphragms very rare in autozooecia, abundant in mesozooecia,

Figs 5–6 *Pedrogopora taylori* gen. et sp. nov.; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. Fig. 5, BMNH PD 8302 (paratype), longitudinal section, showing thin endozonal walls, × 28. Fig. 6, BMNH PD 2642 (**holotype**); 6a, longitudinal section, × 35; 6b, transverse section, showing compressed rounded-polygonal autozooecia in the endozone, × 28; 6c, tangential section, × 28; 6d, tangential section, showing thin-walled space-filling mesozooecia, × 110; 6e, tangential section, showing maculae, × 28.

Fig. 7 *Diplotrypa pseudopetropolitana* Astrova, 1965; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 2626; 7a, longitudinal section, × 28; 7b, tangential section, × 35.

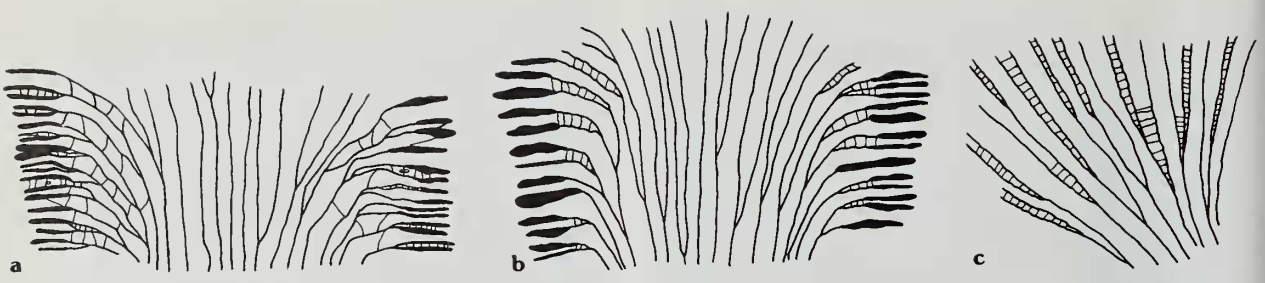


Fig. 8 Longitudinal sketches of the new species described from the Llanbedrog Mudstones. a, *Stigmatella oakleyi*. b, *Pedrogopora taylori*. c, *Diplotrypa nontabulata*.

often constricting chamber width, producing beaded appearance.

DESCRIPTION. Zoaria massive and hemispherical, on average 9·5 mm in diameter. All specimens are fragmentary and no bases are preserved. Autozooecia bud from the basal lamina and curve upwards to the zoarial surface. Autozooecial walls are straight throughout the zoaria, and no differentiation between exozone and endozone can be distinguished. Autozooecia are large with an average diameter of 0·38 mm × 0·44 mm, and are polygonal-circular in transverse section throughout the colony. Diaphragms are absent or very rare in autozooecia; if present they occur in the outermost parts of the autozooecia.

Mesozooecia present, often in abundance, in all zoaria and originate throughout the colony. Maximum diameter averages 0·23 mm; however, there is a large range (0·08–0·44 mm). Mesozooecia are polygonal, often triangular or rectangular, frequently positioned at the autozooecial corners. Mesozooecia contain abundant diaphragms along their entire length. These are basal diaphragms deflected orally at their junctions with the zooecial walls, and spaced on average 0·16 mm apart in the endozone and 0·15 mm in the exozone. Mesozooecia are often constricted at the position of the diaphragms, producing a beaded appearance in longitudinal section.

Autozooecial walls are thin which, combined with poor preservation, results in difficulties in distinguishing wall microstructure. In one specimen (PD 8174) the walls thicken very slightly close to the zoarial surface, reaching a thickness of 0·032 mm. There is an indistinct dark band at the centre of the wall, bordered by lighter bands on either side which have a vague laminar appearance. Within the main body of the zoarium the walls are dark and structureless.

REMARKS. *Diplotrypa nontabulata* sp. nov. is primarily characterized by the rare diaphragms within the autozooecia, small mesozooecia with abundant diaphragms and thin straight walls.

Bork & Perry (1968) described '*Diplotrypa* sp.', from the Guttenberg Formation (Caradoc), Guttenberg, Iowa, U.S.A., which was characterized by the rare autozooecial diaphragms and a small number of mesozooecia with very abundant diaphragms. They only had one specimen and did not consider that a species could be based on a single zoarium. It is certainly very similar to *D. nontabulata* sp. nov., but the Welsh species has more abundant mesozooecia. The Iowa specimen is tentatively assigned to *D. nontabulata* here; the smaller number of mesozooecia may simply reflect intraspecific variation.

Bork & Perry (1968: 341) listed three species of *Diplotrypa* which had few diaphragms: *D. catenulata* Coryell (1921: pl. 10, figs 6, 7) with crenulated zooecial walls; *D. abnormis* (Modzalevskaya) (*in* Astrova, 1965: pl. 28, fig. 1b) with widely-spaced, curved diaphragms throughout the autozooecia; and *D. westoni* Ulrich (1889: pl. 8, figs 4–4b) with occasional diaphragms within the autozooecia.

Genus ***HALLOPORA*** Bassler, 1911

Hallopora cf. ***tolli*** Bassler, 1911 Fig. 10

MATERIAL EXAMINED. BMNH PD 2666; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

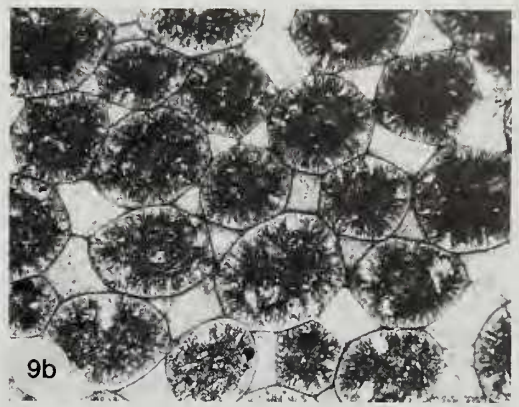
DESCRIPTION. Zoarium erect with small cylindrical branches, on average 5 mm in diameter. Autozooecia are parallel to the branch axis within the endozone and curve outwards gently in the outer endozone to meet the zoarial surface at 80°–90°. The autozooecia within the endozone have thin straight walls. The exozone is narrow with an average width of 0·86 mm. It is recognized by a slight thickening of the zooecial walls and a simultaneous change in zooecial orientation. Autozooecia all originate in the endozone where they are polygonal-rounded in transverse section, becoming oval-rounded in the exozone

Fig. 9 *Diplotrypa nontabulata* sp. nov.; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 8175 (**holotype**); 9a, longitudinal section, showing the lack of diaphragms within the autozooecia, × 25; 9b, tangential section, × 35.

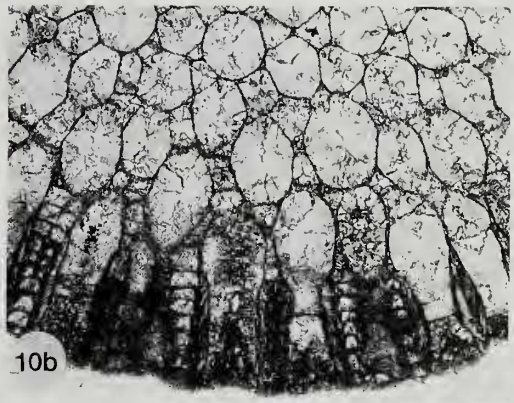
Fig. 10 *Hallopora* cf. *tolli* Bassler, 1911; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 2666; 10a, longitudinal section, × 35; 10b, transverse section, × 35; 10c, tangential section, × 50.

Figs 11–12 *Eridotrypa* cf. *kilbartiensis* Pushkin (*in* Ropot & Pushkin, 1987); Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. Fig. 11, BMNH PD 2722; 11a, longitudinal section showing the exceptionally thickened exozonal walls, × 50; 11b, transverse section, showing large autozooecia in the centre of the endozone, × 50. Fig. 12, BMNH PD 2691, tangential section, × 80.


9a


9b


10a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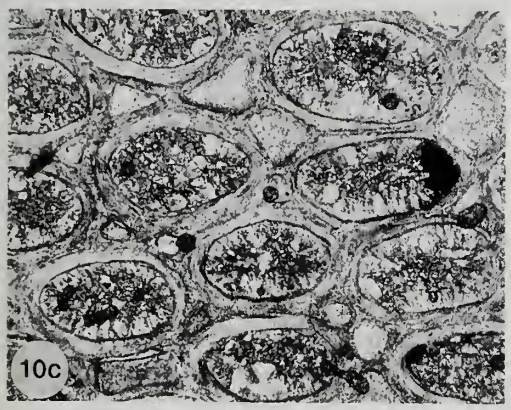
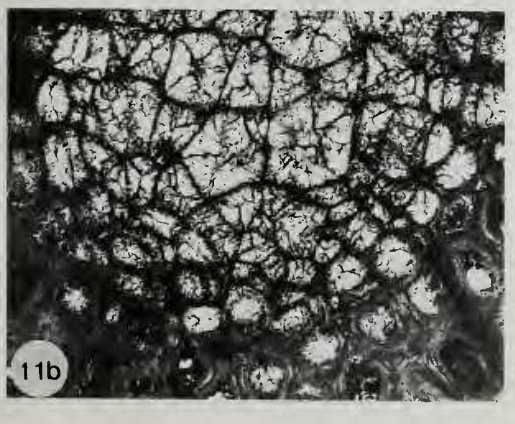
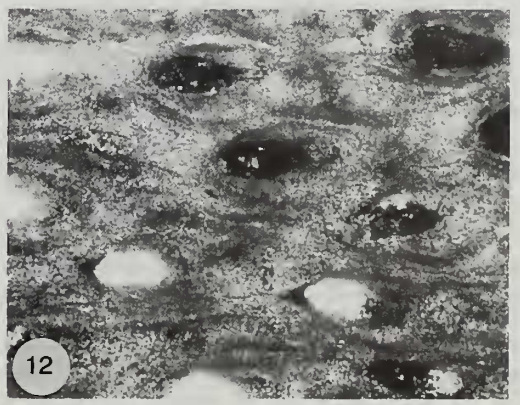

10c


11a


11b


12

as seen in shallow tangential sections of branches. Autozooecial diameters average 0·23 mm × 0·31 mm within the exozone. Diaphragms in the endozone are not abundant and are spaced on average 0·21 mm apart. They are spaced 0·11 mm apart in the exozone. Only one or two diaphragms are found at the outer ends of autozooecia in the exozone. All of these diaphragms are basal, deflected orally at their junctions with the zooecial walls, and their laminae are continuous with autozooecial linings.

Mesozooecia are common, originating in the outer part of the endozone and having a maximum diameter which averages 0·13 mm in the exozone. They are circular to rounded-polygonal in shallow tangential sections. Mesozooecia contain abundant orally-deflected basal diaphragms, spaced on average 0·06 mm apart, which occasionally increase in thickness distally along the mesozooecia.

Autozooecial wall thickness averages 0·08 mm in the exozone. Wall microstructure is composed of steeply inclined, V-shaped laminae. The zooecial wall boundaries are wide, granular areas, most clearly seen in shallow tangential section. Some zooecia are infilled with laminar calcite close to the colony surface. In longitudinal section this infilling consists of broad U-shaped laminae.

Remarks. The single specimen described here is characterized by the ramose colony form and thin-walled autozooecia. Autozooecial apertures are polygonal-rounded in transverse zoarial section and oval-rounded in shallow tangential zoarial section. Rounded-polygonal mesozooecia are common and originate in the endozone. Diaphragms are occasionally present in the outer autozooecia and are abundant in the mesozooecia.

Bassler (1911) described *Hallopora tolli* originally from the Jewe Limestone, Kuckers Shale and Kegal Limestone (Caradoc) of Estonia, and illustrated longitudinal and deep tangential sections. This species has long, straight mesozooecia with abundant diaphragms, similar to the Welsh specimen. The autozooecia are polygonal-rounded in tangential section (their shape in zoarial transverse section is not known). However, Bassler's section is very deep and is difficult to compare directly with that of the Welsh specimen. Fritz (1941) described *H. tolli* from the Whitehead Formation, Gaspé, Québec, Canada, but her description is not well illustrated. Bork & Perry (1967) tentatively described one fragmentary specimen as *H.* cf. *tolli* from the Guttenberg Formation (Caradoc) of Iowa, U.S.A. It differs from the specimen illustrated by Bassler in having thinner walls. Until the type material of *H. tolli* has been re-examined, the true nature of the species will remain obscure. Because of this the poorly preserved Welsh specimen is named *H.* cf. *tolli*.

Singh (1979) proposed the genus *Parvohallopora* for some species previously assigned to *Hallopora*. He distinguished the two genera on the basis of the following characteristics: in *Parvohallopora*, zooecia are of smaller diameter than in *Hallopora*; mural spines are absent in *Parvohallopora* but are present in the type species of *Hallopora*; mesozooecia are generally smaller in *Parvohallopora*; zooecia are polygonal in the endozone of *Parvohallopora*, whereas in *Hallopora* they are rounded to subrounded; cystose diaphragms are rare to absent in *Parvohallopora* but are more common in *Hallopora*; and the laminae of adjacent zooecia are broadly U/V-shaped in *Parvohallopora* and distinctly V-shaped in *Hallopora*.

The present specimen is assigned to *Hallopora*, despite the possession of certain characters attributed to *Parvohallopora*: the endozonal zooecia are polygonal-rounded and the mesozooecia are small, both characteristics of *Parvohallopora*. However, the occasional presence of diaphragms in the autozooecia and the V-shaped laminae in the zooecial walls are attributes of *Hallopora*. This seems to show that the distinction between the two genera is less clear-cut than Singh suggests.

Genus ***ERIDOTRYPA*** Ulrich, 1893

Eridotrypa cf. ***kilbartiensis*** Pushkin (*in* Ropot & Pushkin, 1987) Figs 11–12

Material examined. BMNH PD 2691, 2720, 2722; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

Description. Zoaria erect with very narrow cylindrical branches, on average 2·5 mm in diameter. The three specimens from Llanbedrog are poorly preserved. Autozooecia are parallel to the branch axis within the endozone and then curve slightly in the exozone to meet the zoarial surface at 45°. The autozooecia within the endozone have thin, straight walls. The exozone is narrow with an average width of 0·76 mm; it is recognized by an extensive thickening of the zooecial walls. Autozooecia all originate in the endozone and are polygonal in transverse section, becoming oval in the exozone as seen in tangential sections of branches. In transverse section the autozooecia are twice the diameter in the inner endozone than in the outer endozone. Autozooecial diameters average 0·10 mm × 0·12 mm within the exozone. Diaphragms are present in the outer endozone and exozone, spaced on average 0·11 mm apart. These basal diaphragms are all deflected orally at their junctions with zooecial walls.

No mesozooecia have been conclusively identified in the three specimens examined.

Acanthostyles have been observed in the exozone of one specimen (PD 2722). They are short and composed of a hyaline calcite core surrounded by steeply dipping laminae.

Autozooecial walls are thick in the exozone. Wall microstructure is composed of steeply inclined, V-shaped laminae (microstructure is slightly indistinct due to the age and thickness of the thin sections). Zooecial boundaries have not been distinguished. Some zooecia are infilled with laminar calcite close to the zoarial surface. In longitudinal section this infilling consists of broad U-shaped laminae.

Remarks. The three poorly preserved specimens from Llanbedrog assigned to *Eridotrypa* cf. *kilbartiensis* Pushkin are characterized by their slender branches, and autozooecial walls which are thin and straight in the endozone and thicken in the exozone. Autozooecial apertures are large and polygonal in transverse section, small and oval in shallow tangential sections. Diaphragms are present in the exozonal autozooecia and occasionally in the endozone.

The specimens are very similar to *E. kilbartiensis* Pushkin (*in* Ropot & Pushkin, 1987), described from the Oanduskii Stage (Caradoc), White Russia. *E. kilbartiensis* has thin, straight walls in the endozone which thicken extensively in the exozone (Ropot & Pushkin 1987: pl. 14, figs 3a, b). The major difference is the greater number of diaphragms in the exozone of the Welsh specimens. There may be range of variability within the species, but until further material can be

examined, the Welsh material is tentatively identified as *E.* cf. *kilbartiensis*.

Family **MONTICULIPORIDAE** Nicholson, 1881

Genus ***PRASOPORA*** Nicholson & Etheridge, 1877

Prasopora grayae Nicholson & Etheridge, 1877 Figs 13–15

1877 *Prasopora grayae* Nicholson & Etheridge: 392.
1881 *Monticulipora (Prasopora) grayae* Nicholson & Etheridge; Nicholson: 203; figs 42–43.
1987 *Prasopora grayae* Nicholson & Etheridge; Ropot & Pushkin: 190; pl. 22, fig. 4.

LECTOTYPE. Selected herein from the type locality, BMNH D 32195 (a longitudinal thin section); Craighead Beds (Upper Ordovician), Craighead Quarry, Ayrshire, Scotland. This specimen is possibly one of the original ones figured by Nicholson & Etheridge (1877: fig. D). A tangential section (BMNH D 32196) may be part of the same colony.

MATERIAL EXAMINED. BMNH PD 2627, 2699; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

OTHER OCCURRENCE. Kukrusean Stage (Upper Llandeilo/Early Caradoc), White Russia, U.S.S.R.

DESCRIPTION. Zoaria hemispherical, on average 11 mm in diameter. The basal lamina, observed only in thin section, is thin and the microstructure indistinct. Autozooecia all originate at the base of the colony and gently curve upwards to the zoarial surface. Autozooecial walls are straight and quite thin throughout most of the colony. No differentiation between the endozone and the exozone can be recognized. In the periphery of the colony the autozooecia are rounded-polygonal in shallow tangential sections, with average diameters of 0·41 mm × 0·31 mm. Diaphragms and cystiphragms are common throughout the autozooecia, occurring together or alone. The diaphragms are basal and are all deflected orally at their junctions with the zooecial walls. The diaphragms are thin and spaced on average 0·1 mm apart in the endozone and 0·12 mm apart in the exozone. Cystiphragms are very abundant, usually present with diaphragms. They occur either on both sides of the autozooecia or confined to one side; this side, however, is not constant throughout the colony and they may be arranged centripetally.

Mesozooecia are numerous, and originate in the inner parts of the colony. They are rounded in transverse section and have a maximum diameter which averages 0·13 mm. Mesozooecia contain abundant orally-deflected diaphragms along their entire length. The diaphragms are spaced on average 0·06 mm apart.

Autozooecial walls are thin throughout the colony. Wall microstructure is composed of inclined U-shaped laminae which may, however, be hard to distinguish. Zooecial boundaries are indistinct dark regions.

REMARKS. *Prasopora grayae* is characterized by the hemispherical colony form; autozooecial apertures which are rounded-polygonal in shallow tangential zoarial sections; diaphragms and cystiphragms which are very abundant in the autozooecia; and common diaphragms in the small mesozooecia.

P. grayae was originally described from the Craighead Beds of Girvan by Nicholson & Etheridge (1877). Abundant specimens of this species are available for study at the Natural History Museum. Although zoaria from Scotland are larger than the Welsh specimens, zooecial apertures are of similar size. *P. grayae* has also been described from the Kukrusean Stage, White Russia, U.S.S.R, by Ropot & Pushkin (1987).

The lectotype (Fig. 13) of *P. grayae* is herein selected from the original 'Gray' collection described by Nicholson & Etheridge (1877). This particular colony has abundant 'brown-bodies' within the autozooecia (Figs 13a, c). These are granular deposits of iron oxide or pyrite, which are considered to represent the fossilized remains of organic material (Boardman & Cheetham, 1983).

P. insularis Ulrich var. *estonica*, described by Modzalevskaya (1953: 106) from the western Russian Platform, is similar to *P. grayae* but differs in having more abundant cystiphragms within the autozooecia and fewer diaphragms. *Prasopora* has been commonly recognized in North America (e.g. Ross, 1967), but the species *P. grayae* has never been recorded.

Prasopora thorali Prantl, 1940 has also been recognized from Llanbedrog: see below. It differs from *P. grayae* in having fewer mesozooecia and larger, less abundant cystiphragms.

Prasopora thorali Prantl, 1940 Figs 16–17

1940 *Prasopora thorali* Prantl: 89, figs 2, 3; pl. 1, fig. 10.
1948 *Prasopora thorali* Prantl; Dreyfuss: 42; pl. 1, figs 1–9.
1948 *Prasopora thorali* var. *elliptica* Dreyfuss: 25.

HOLOTYPE. Illustrated in Prantl (1940: pl. 1, fig. 10); east of Grange du Pin, Herault (Ashgill), Montagne Noire (Languedoc).

MATERIAL EXAMINED. BMNH PD 2687, 2689; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

DESCRIPTION. Zoaria hemispherical, on average 30 mm in diameter. Only fragmentary specimens of this species are known from Wales and no surface detail is preserved.

Autozooecia all originate at the base of the colony and gently curve upwards to the zoarial surface. Autozooecial walls are straight and quite thin throughout most of the colony.

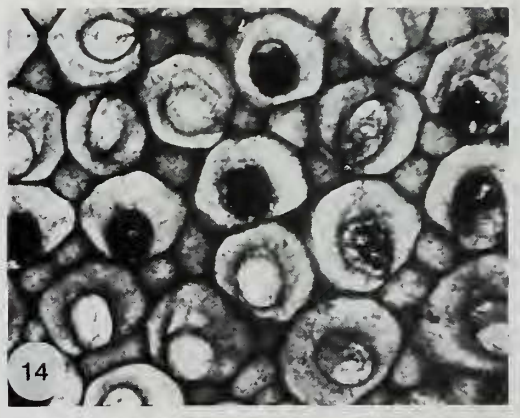
No differentiation between endozone and exozone can be recognized. The autozooecia are polygonal in shallow tangential sections, with an average diameter of 0·35 mm × 0·43 mm. Diaphragms and cystiphragms are common throughout the autozooecia, occurring together or alone. The diaphragms are basal and are all deflected orally at their junctions with the zooecial walls. The diaphragms are thin and spaced on average 0·17 mm apart in the endozone and 0·14 mm in the exozone. Cystiphragms are very abundant, usually present with diaphragms. They are almost always confined to one side of the autozooecia, but which side is not, however, constant throughout the colony. The cystiphragms may be centripetally arranged with respect to the maculae.

Mesozooecia are present, although very rare, and originate in the inner parts of the colony. They are polygonal in transverse section and have a maximum diameter which averages 0·14 mm. Mesozooecia contain abundant orally deflected diaphragms along their whole length. The diaphragms are spaced on average 0·1 mm apart.


13a


13b


13c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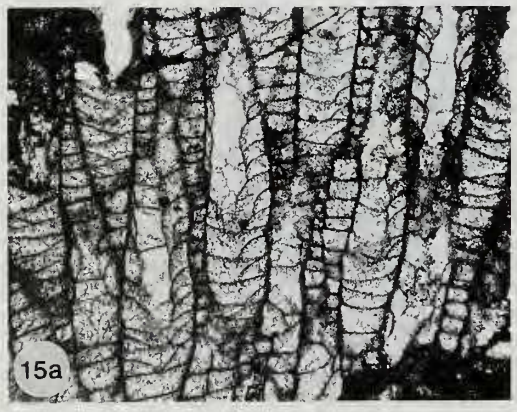
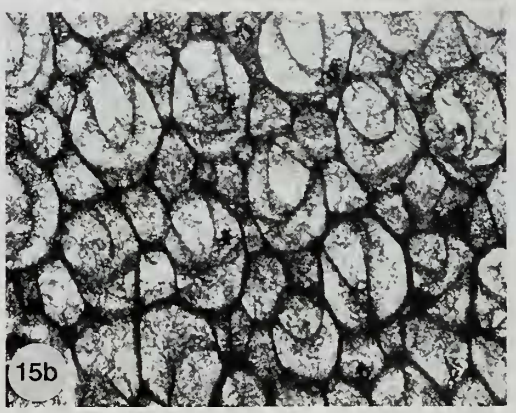

15a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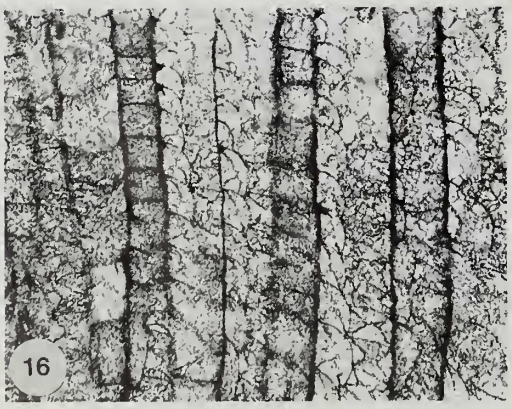
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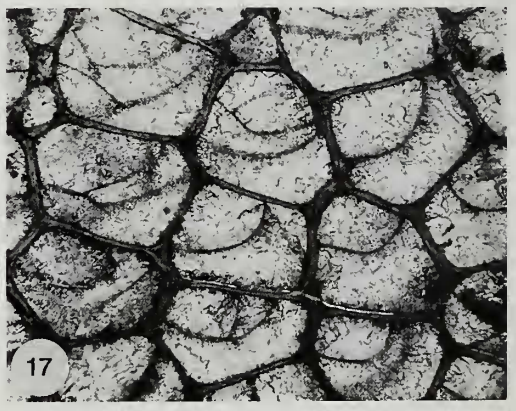
17

Autozooecial wall thickness averages 0·03 mm at the periphery of the colony. Wall microstructure is composed of inclined U-shaped laminae, and zooecial boundaries are dark and granular.

REMARKS. *Prasopora thorali* was first described by Prantl (1940) from the Upper Ordovician of the Montagne Noire in France. The species is characterized by a hemispherical to subconical colony form and subpolygonal autozooecial apertures (0·36–0·39 mm in diameter). Maculae are present and contain slightly larger autozooecia than in the rest of the colony. Cystiphragms are present in autozooecia and generally form continuous rows on one side of zooecia (three cystiphragms per mm). Diaphragms are commonly present in conjunction with the cystiphragms or without them. Zooecial walls are thin throughout the colony. Mesozooecia are rare and have abundant diaphragms (4–6 per mm). Small, indistinct acanthostyle-like structures have been recognized.

The measurements of the specimens from Llanbedrog overlap those from France, although the former generally have a larger range.

Dreyfuss (1948: 25) described *P. thorali* var. *elliptica*, which differed from *P. thorali* by having more numerous regular cystiphragms in the autozooecia. No illustrations were provided and the number of cystiphragms cited falls within the present extended range, so this variety is placed in synonymy with *P. thorali*.

Genus ***MESOTRYPA*** Ulrich, 1895

Mesotrypa sp. Fig. 18

MATERIAL EXAMINED. BMNH PD 8297; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

DESCRIPTION. Zoarium hemispherical, on average 8 mm in diameter. No exterior or basal details are preserved on the one known specimen. Autozooecia bud from the basal laminae and curve outwards to the zoarial surface; new zooecia are also intercalated above the basal laminae. The autozooecial walls are straight and thin throughout most of the colony. At the periphery of the colony the autozooecia are rounded-polygonal in shallow tangential sections, with an average maximum diameter of 0·34 mm. Diaphragms are very rare; only one has been recognized and is located in the outer part of an autozooecium.

Mesozooecia are very abundant and originate throughout the colony. They are polygonal, often triangular, in transverse section and have a maximum diameter which averages 0·17 mm. Mesozooecia contain abundant orally-deflected basal diaphragms throughout their length. The diaphragm laminae are continuous with autozooecial linings. They are spaced on average 0·12 mm apart in the endozone and 0·11 mm in the exozone, often increasing in thickness towards the distal end of the mesozooecia. Mesozooecia are often constricted at the position of the diaphragms, producing a beaded appearance in longitudinal section.

Acanthostyles are abundant and have an average diameter of 0·04 mm. They are located throughout the colony, having a greater abundance in the outer portions. They can indent autozooecial walls and in longitudinal section acanthostyles are observed protruding into the zooecia. A hyaline calcite core is surrounded by steeply dipping laminae.

Autozooecial walls are thin at the periphery of the colony. Wall microstructure is composed of inclined U-shaped laminae, and zooecial boundaries are indistinct. Walls are disrupted by the numerous acanthostyles making the microstructure difficult to distinguish.

REMARKS. Only one specimen of the genus *Mesotrypa* has been identified from the Llanbedrog Mudstones. This specimen is characterized by the hemispherical colony form, large autozooecia with thin straight walls, a rounded-polygonal aperture in tangential section and common mesozooecia. Diaphragms are rare in the autozooecia and common in mesozooecia. Acanthostyles are large and present throughout the colony.

Two species of *Mesotrypa* have been previously described from the Welsh Basin. *Mesotrypa lens* (M'Coy, 1850) was described by Spjeldnaes (1957:368) from the Caradoc Series of Horderly West, Shropshire. In the description of this species the absence of acanthostyles was noted. This suggests that the specimens may not belong to the genus *Mesotrypa*. A re-examination of these specimens is required. Ross (1963: 6) identified a new species, *M. bulmani*, from the Hoar Edge Group (Caradoc Series) of Shropshire. This species differs primarily from the Llanbedrog species in the presence of numerous diaphragms within the autozooecia and the sparse mesozooecia.

Mesotrypa strumaeformis, described by Pushkin (*in* Ropot & Pushkin, 1987: 156) from the Oanduskii and Rakverskii Stages (Middle Caradoc), Yuzhnoi, Pribaltiki, U.S.S.R., has similarities with the specimen from Llanbedrog. Diaphragms are absent in all the autozooecia, and the zooecia have similar diameters in both taxa. The major difference is the size of the acanthostyles which are up to three times larger in the Welsh specimen than in *M. strumaeformis*.

Suborder **CERAMOPORINA** Bassler, 1913
Family **CERAMOPORIDAE** Ulrich, 1882

Genus ***CERAMOPORELLA*** Ulrich, 1882

Ceramoporella distincta Ulrich, 1890 Fig. 19

1890 *Ceramoporella distincta* Ulrich: 464; pl. 39, figs 6, 6a.
1908 *Ceramoporella distincta* Ulrich; Cumings: 799; pl. 10, fig. 7; pl. 11, figs 2, 2a.

Figs 13–15 *Prasopora grayae* Nicholson & Etheridge, 1877; Figs 13–14, Craighead Beds (Upper Ordovician), Craighead Quarry, Ayrshire, Scotland. Fig. 13, BMNH D 32195 (**lectotype**, herein selected); 13a, longitudinal section, × 15; 13b, longitudinal section, showing an autozooecium developing from a mesozooecium-like polymorph, × 35; 13c, longitudinal section, showing a 'brown-body' within the autozooecium, × 85. Fig. 14, BMNH D 32196 transverse section, showing 'brown-bodies' within the autozooecia, × 85. Fig. 15, Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 2699; 15a, longitudinal section, × 30; 15b, tangential section, × 45.

Figs 16–17 *Prasopora thorali* Prantl, 1940; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. Fig. 16, BMNH PD 2687, longitudinal section, × 30. Fig. 17, BMNH PD 2689, tangential section, × 45.

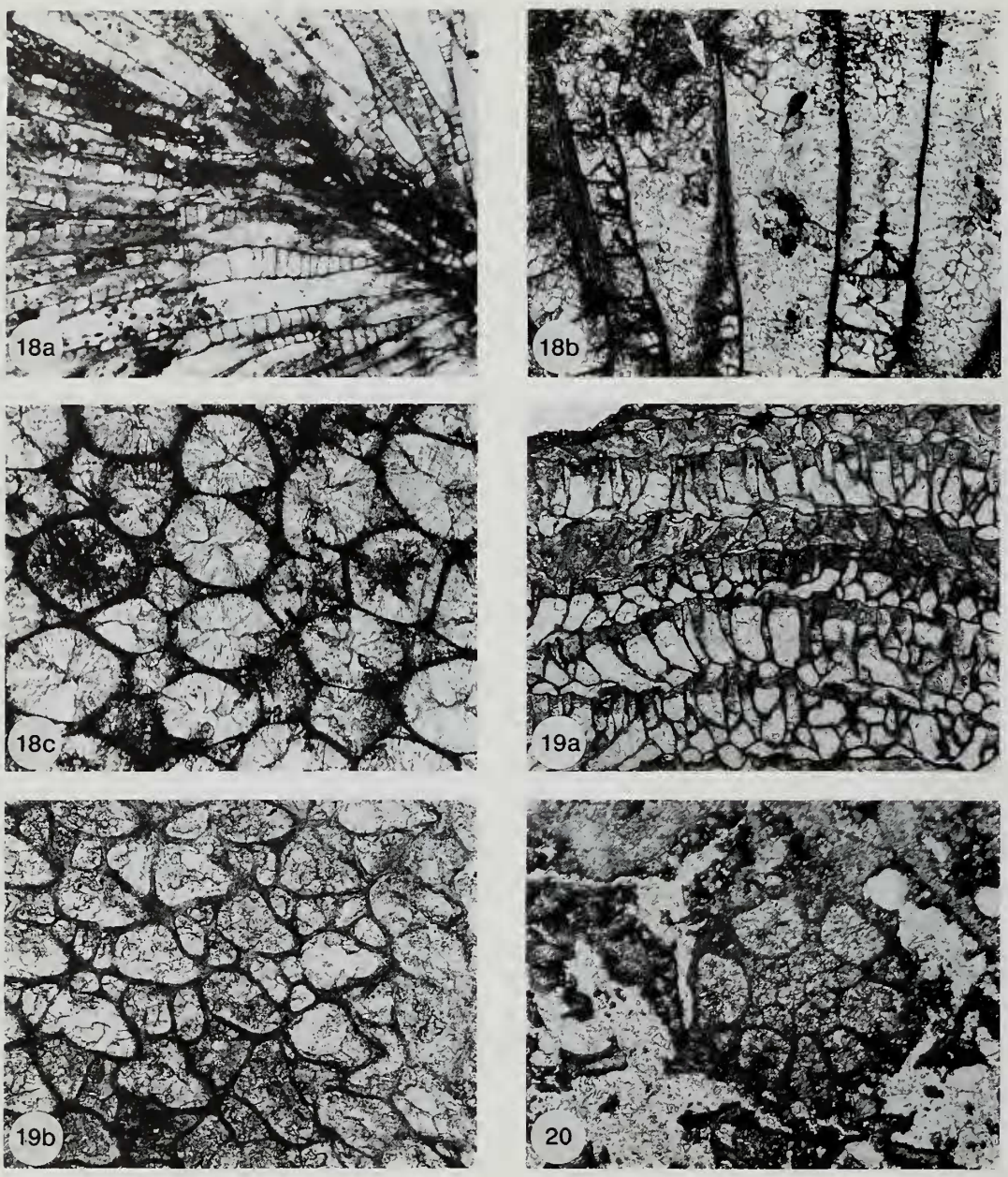

Fig. 18 *Mesotrypa* sp.; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 8297; 18a, longitudinal section, × 15; 18b, longitudinal section, showing large acanthostyles in the exozone, × 40; 18c, tangential section, × 40.

Fig. 19 *Ceramoporella distincta* Ulrich, 1890; Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 2642a; 19a, longitudinal section, showing the encrusting nature of the colony, × 15; 19b, tangential section, × 30.

Fig. 20 *Kukersella borealis* (Bassler, 1911); Llanbedrog Mudstones (Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales. BMNH PD 2652f, transverse section, × 70.

1909 *Ceramoporella distincta* Ulrich; Grabau & Shimer: 122.
1953 *Ceramoporella distincta* Ulrich; Bassler: figs 44, 2a, b.
1968 *Ceramoporella distincta* Ulrich; Utgaard: 1405; pl. 181, fig. 4; pl. 182, figs 1–3.
1973 *Ceramoporella distincta* Ulrich; Utgaard: figs 16, 23.
1984 *Ceramoporella distincta* Ulrich; Karklins: I89; pl. 38, figs 1, 4.
1991 *Ceramoporella distincta* Ulrich; Buttler: 100; pl. 6, figs 5–8.

LECTOTYPE. USNM 159710, McMiken strata of Eden Formation (Upper Ordovician), Cincinnati, U.S.A. (sel. Utgaard, 1968).

MATERIAL EXAMINED. PD 2642a, Llanbedrog Mudstones

(Soudleyan, Caradoc), near Llanbedrog, Gwynedd, Wales (SH 322314).

OTHER OCCURRENCES. Eden and Waynesfield Formation, Cincinnati; Brannon and Millersburg Members, Shermanian Stage, Lexington Limestone, Kentucky; Slade and Redhill Beds (Ashgill), near Whitland, Dyfed, Wales.

DESCRIPTION. Zoarium encrusting, consisting of up to five superimposed layers of autozooecia. The basal layers, observed in thin section, are thick (on average 0·79 mm) and the basal laminae of the layers have a laminated microstructure.

It is hard to distinguish endozone from exozone. In the endozone the autozooecia are slightly recumbent and zooecial walls are thin and straight. In the exozone the walls remain straight and zooecial apertures in shallow tangential section are circular-polygonal and on average 0·26 mm in diameter. Lunaria are abundant throughout the colony.

Diaphragms are occasionally present in the autozooecia. They are subterminal, aborally deflected and continuous with the zooecial linings. These diaphragms frequently occur at the same level in adjacent zooecia. Basal diaphragms are rare.

Small exilazooecia are present in the outer endozone and exozone. These contain no diaphragms and are rounded in shallow tangential section, on average 0·09 mm in diameter.

Communication pores have not been observed. Possible acanthostyle-like structures have been observed but not identified conclusively. The microstructure is hard to distinguish but appears to be laminar.

REMARKS. The species is characterized by the multilayered zoaria, thin autozooecial walls, sparse diaphragms and the presence of distinct lunaria. It is very similar to *Ceramoporella distincta* Ulrich, 1890, recently re-described by Karklins (1984: 189), from the McMiken Member, Eden Formation (Upper Ordovician), Cincinnati, Ohio, U.S.A. The main difference is that the specimens from Wales have fewer exilazooecia than those of North America. Similar specimens have been described from the Slade and Redhill Beds (Ashgill), near Whitland, Dyfed, Wales (Buttler 1991).

Order **CYCLOSTOMATA** Busk, 1852
Family **CROWNOPORIDAE** Ross, 1967
Genus ***KUKERSELLA*** Toots, 1952

Kukersella borealis (Bassler, 1911) Fig. 20

DESCRIPTION. Colony erect with narrow subcylindrical branches (average diameter 1·08 mm), arising from an encrusting base. Endozonal zooecia are very thin walled and are orientated parallel to the branch growth-direction to form an axial bundle. The endozonal zooecia only reach the colony surface at the distal growth tips. Abundant, closely spaced (0·09 mm) diaphragms occur throughout the length of the endozonal zooecia and are deflected orally at their junction with vertical interzooecial walls.

Exozonal zooecia surround the axial bundle of endozonal zooecia. They are thick-walled, average 0·48 mm in length and are connected by sparse interzooecial pores which penetrate interzooecial walls at levels close to the colony surface. Occasional diaphragms are developed at levels close to the colony surface; they are deflected orally where they meet the interzooecial walls. Frontal walls of exozonal zooecia have distal subcircular apertures with an average diameter of 0·15 mm and slight peristomes. The frontal walls are densely pseudoporous. The pseudopores are variable in size, but consistantly large, on average 0·02 mm in diameter. They are crater-like in external morphology, with funnel-shaped openings. The encrusting bases are composed entirely of exozonal wall material.

REMARKS. A redescription and complete synonymy list of *K. borealis* is given in Buttler, 1989.

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